

AMENDMENTS TO THE SPECIFICATION

Please amend as indicated below.

(a) Amend paragraph 0009 as indicated below.

[0009] Of particular significance are the amounts and types of salts available in a given type of soil. These vary to a great extent from one location to another. ~~Another important cause~~ Other important causes of variations in soil conductivity are associated with variations in soil acidity or alkalinity (soil pH variations). These also have significant effects on the conductivity of the soil and make it difficult to reliably determine moisture for various soils. Accordingly, such variations make determining ground moisture using conductive sensors unreliable.

(b) Amend paragraph 0022 as indicated below.

[0022] Fig. 1 is a block diagram of an irrigation system including in particular an irrigation control system 100 according to one embodiment of the invention. The control system 100 includes a timer or time clock 101 which preferably serves as both a clock and watering period timer. Timer 101 may be in the form of a solid-state programmable device, a an electro-mechanical clock, or any other suitable construction. Clock 101 is advantageously coupled to a source of suitable operating power such as alternating current (A.C.) power, such as from the electrical mains of an electrical power supply system. Timer 101 has an output terminal or terminals 103 from which a timer control signal is conducted. The voltage output from terminal 103 is preferably reduced from the mains voltage power

input to the timer. This is done for safety and efficiency considerations, such as by using a nominal 24 volt A.C. output at terminal 103.

(c) Amend paragraph 0030 as indicated below.

[0030] Sensor 102 is preferably used with ancillary circuit 104 in a manner which places these components in close proximity and under similar conditions. This may be done such as by physically coupling ancillary circuit 104 to sensor 102. Spacing of these units within less than 1 foot is preferred for reliable results, and is more preferably arranged to be 0-3 inches, even more preferably less than about 1 inch. In a preferred embodiment, ancillary circuit 104 and sensor 102 are each enclosed and the enclosures are directly coupled together such that a singular physical unit is formed. The ancillary circuit is preferably enclosed or ~~imbedded~~ embedded in a moisture resistant material, such as a plastic. The sensor is provided with a water-permeable shell.

(d) Amend paragraph 0043 as indicated below.

[0043] Further included in system 150 is a controller 152 coupled to the connection 124 and receiving electrical power therefrom, as controlled by the master valve output signal of timer 101. Controller 152 is similar in operation to controller 106 described above. Controller 152 has multi-channel capability to independently sense and control two separate irrigation zones 154 and 156. This multi-zone capability is accommodated by zone output terminals which are separately communicated by conductors 162 and 164 to individual zone control input terminals on controller 152. The master valve signal is used

to provide basic operating current via conductors 125, isolation transformer 108 and conductor 124. The zone control signals communicated by conductors 162 and 164 ~~and~~ are received within controller 152 using an optical isolator, such as an optical triac (as described below). This construction helps achieve isolation from the electrical ground currents mentioned above or other spurious currents which may affect operation or cause malfunction.

(e) Amend paragraph 0045 as indicated below.

[0045] Each of the zones 154 and 156 separately ~~include~~ includes an ancillary circuit 104 and a sensor 102. The zones also each have a zone control valve 110. One or a plurality of sprinkler heads 112 are coupled to the hydraulic output of valves 110 by way of piping 114. Each of the valves 110 are also coupled to a source of irrigation water 111. These elements 102, 104, 110, 112 and 114 function substantially as described above for the first embodiment. System 150 also includes ground unit cables 120 and valve control cables 122 associated with each of the zones 154 and 156.

(f) Amend paragraph 0061 as indicated below.

[0061] Further included in the preferred sensor circuit 104 is a rectifier or rectification stage which is principally provided in the form of an NPN transistor 192 and rectifier filter capacitor 194. The base of transistor 192 is connected to node C which is operating at an alternating or varying voltage under the influence of oscillator 184. The collector of transistor 192 is connected to node B. The emitter of transistor 192 is

connected to a node between one ~~electride~~ electrode of rectifier filter capacitor 194 and to a first side of resistor 193. The action of the rectifier helps transform the voltage at the other or second side of resistor 193 into a fluctuating direct current signal indicative of moisture level sensed by sensor 102.

(g) Amend paragraph 0063 as indicated below.

[0063] Fig. 3 shows that the ancillary circuit 104 includes ground or communications signal line filter capacitor 199. This is particularly desirable to help filter out 60Hz or other undesirable frequencies that may arise on the V- or negative of power supply conductors 182. Reduction or elimination of these spurious, undesirable frequencies is significant in helping the relatively sensitive sensor and related detection circuit described above to be isolated from currents that may cause the sensed moisture signal to be variable and hence unreliable.

(h) Amend paragraph 0077 as indicated below.

[0077] In a preferred embodiment, conductors 204 and 206 comprise ~~twenty-eight~~ twenty-eight gauge, double enamel coated conductors, making about thirty complete turns about support 202, with a separation distance 210 of about 0.1-0.2 inch (~2-5 millimeters). Other sizes, spacings and configurations for conductors 204 and 206 are possible consistent with the teachings of this invention. In the sensor construction described herein, an intact set of electrode conductors should not have conductive leakage between

the electrodes. Leakage should be small enough to demonstrate not less than 20 megohms of resistance between the capacitive sensor electrodes when wet.

(i) Amend paragraph 0078 as indicated below.

[0078] Each of the conductors 204 and 206 have has opposing ends which are preferably connected so as to form electrical nodes 214 and 216, respectively. Such nodes are preferably connection points for the sensor into the circuit as described above (nodes A and D of Fig. 3). In this way, each of the conductors 204 and 206 ~~form~~ forms a loop. The two loops are arranged in complementary relationship, such as the parallel helical spirals described.

(j) Amend paragraph 0083 as indicated below.

[0083] The preferred sand fill 208 also serves to maintain the positions of support 202, conductors 204 and 206, and shell 200 in a substantially fixed orientation and relationship to one another. This helps to provide repeatable results and thus allows a sensor design which achieves linear or near-linear response and ~~maintain~~ maintains such response characteristics. Such also provides mechanical strength to the shell and entire structure of the sensor so that it can be planted into the ground in a relatively close position to the surface of the ground and survive typical service. Such service may be subjected to overburdens and loading from soil, traffic, vehicles, mowers, etc.

(k) Amend paragraph 0088 as indicated below.

[0088] The preferred sensor parameters indicated above provide a sensor having electrical capacitance between nodes 214 and 216 in the range of about 100 picofarads when the sensor 102 is in very dry conditions; and about 1,000 picofarads when the sensor 102 is in very wet conditions. Other ranges of electrical capacitance associated with other sensor configurations will occur. Modification to circuit values may be needed if different ranges of sensed capacitance ~~[[is]]~~ are produced in any particular sensor construction being used. Thus the sensor and excitation and detection circuitry are best designed and tested to achieve suitably linear results, or other compensation circuitry may be needed.

(l) Amend paragraph 0089 as indicated below.

[0089] In typical operation sensor 102 performs as follows. Sensor 102 is buried in direct contact with the earth. This may suitably be accomplished by burial entirely in the earth at a location within or near an irrigation zone to be sensed and ~~controlled.~~ controlled; for example, within earth 118 of irrigation zone area 130 as shown in Fig. 1. The sensor preferably has continuous contact between the outer surface of the shell 200 and the earth. Moisture in the ambient earth migrates through the water permeable shell 200 and into fill 208 of sensor 102. The migrated moisture affects the capacitance and reactive capacitance demonstrated between the electrodes due to the dielectric constant or permittivity properties of fill 208. This in turn indicates the moisture content or water concentration of the ambient earth. Thus, the electrical capacitance developed between the electrodes of sensor 102 is indicative of the moisture contained in the ambient earth.

The moisture migrational responsive characteristics of the sensor may be varied if the application requires frequent watering sessions, thus needing greater moisture migration rates. The current sensor has been found suitable for lawn watering requirements.

(m) Amend paragraph 0098 as indicated below.

[0098] Controller 106 may also advantageously ~~includes~~ include an LED indicator 274 coupled to the result signal 270 or other suitable connection. Indicator LED 274 provides a visual indication of the status of the result signal 270. This is typically constructed to have the LED on when moisture is high and watering is prevented.

(n) Amend paragraph 0106 as indicated below.

[0106] At this point, the sensor operating period begins, as established by counter 280. In a preferred embodiment, the sensor operating period has a duration of about thirty seconds. The warm-up period is established as the first seventeen seconds of the ~~thirty-second~~ thirty-second sensor operating period. The sensing period is the remainder. Other time periods associated with other embodiments of controller 106 are possible. Immediately after the counter begins, the bridge enable signal 292 is asserted ON by the counter 280, and will stay on for the duration of the sensor operating period. Switch 282 responds to the assertion of the bridge enable signal 292 by conducting D.C. electrical power from power supply node 254 to circuit 104 via conductor 182 of cable 120. Note that at this point, the valve enable signal 299 remains in an OFF or deactivated state.

(o) Amend paragraph 0117 as indicated below.

[0117] Bridge circuit 300 further includes an oscillator 318 which is coupled to and derives its operational power from voltage regulator output line 310 and ground line 314. Oscillator 318 includes output signal lines 320 and 322. Oscillator 318 provides a substantially square wave output signal having a frequency of about 125kHz and an amplitude of about 5-7 volts peak-to-peak. The signal output is coupled to a capacitor bridge arrangement 328 at nodes C and D, by way of respective coupling capacitors 324 and 326. The coupling capacitors 324 and 326 serve to provide an A.C. signal coupling and at the desired oscillator frequency and diminishment of other frequencies.

(p) Amend paragraph 0122 as indicated below.

[0122] In step 604, the controller 106 responds to the provision of 24VAC power by transitioning through a reset condition. Then, the controller 106 begins an ~~internally-established~~ internally established sensing time period, during which electrical power is provided to ancillary circuit 104 and a sensor 102 arrangement by way of a corresponding cable 120.

(q) Amend the Abstract as indicated below.

ABSTRACT OF THE DISCLOSURE

Irrigation systems, moisture sensors and related methods having a sensor ~~imbedded~~ embedded in the ground to sense moisture and help control watering. The sensor is responsive to capacitance changes from ground moisture variations. The sensor uses

spaced insulated electrodes which are mounted within a granular filled chamber within a water-permeable shell. The sensor is mounted as part of a ground unit that also includes a high frequency driver that excites the sensor. The ground unit further has a detector circuit which produces a moisture indicating signal based on the capacitance which varies with ground moisture. Also disclosed are controllers that electrically isolate the ground units so that reliable moisture signals can be obtained and used to control irrigation. The controllers can be configured to provide multiple zone operation using a shared controller having shared or independent moisture adjusters.